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Ecology of Sri Lankan Dry Forests: Implications for the Conservation Management of Northernmost Dry Forests

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Abstract: This study assesses some floristic and physiognomic features and threats prevailing in dry forests at three localities: Bandaraketiya in Victoria-Randenigala-Rantambe sanctuary (in Badulla District), Bundala National Park (in Hambanthota District) and Manewakanda (in Anuradhapura District) and compares these with the situation in a dry forest in the Kilinochchi District to prescribe conservation and management guidelines for northernmost dry forests of the country. The density of individuals, the number of strata in the vegetation profile, species composition and the endemic and threatened plant species present in four forests were not comparable. These may be artefacts of their physical location and subsequent variations in the climate and the nature of disturbances (the type, frequency and magnitude). However, some climax forest species appear to be more site-specific but most of the early seral species show a wide distribution throughout the whole dry zone of the country. Selective logging and subsequent severe grazing and browsing prevent the re-establishment of native climax tree species but pave the path for invasive species to occupy the forests. Therefore, floristically rich northernmost dry forests of Sri Lanka should be protected from selective logging and other anthropogenic activities such as clearance and cattle ranching. Policies should be formulated to conserve these unique dry forests and to prevent conversion, fragmentation and illegal human activities in them. Measures should be taken to introduce ecotourism industry to the area while conserving the forests and their biodiversity. Promoting to grow native dry forest timber tree species in home gardens of local villagers together with some fodder and fuel wood tree species would be beneficial in protecting the northernmost dry forests in the long run.

Keywords: Conservation, Disturbances, Dry Forest, Floristic and Physiognomic features.

I. Introduction

Natural forests are sources for many hidden treasures to the local people as these harbour pollinators or predators of agricultural pests, protect the ground water table and ameliorate the environment in addition to providing tangible benefits such as timber, fuel wood and medicinal plants. Dry forests of Sri Lanka are no different from other tropical forests in these aspects. These are valuable resources that provide many tangible and non-tangible benefits. However, these forests frequently get disturbed by anthropogenic activities such as selective logging and shifting cultivation [3, 5, 6, 8, 12, 13] and due to plant invasions.

As a result, successional forests at different ages or disturbance regimes are formed [11, 13]. Frequent disturbances would pave the path to form *plagioclimaxes* locally known as 'scrub jungles' through deflected succession [7]. Moreover, the regeneration of natural dry forests is found to be very low [4, 6–8, 10–14] and the poor quality and quantity of the seed rain [12], soil seed bank [9, 12, 13] and the seedling bank [13] are responsible for this. Unplanned human activities may lead to damage these vulnerable ecosystems and therefore, careful planning is essential if these forests are used in post-war developmental activities.

Dry forest tree species in the northernmost region of Sri Lanka had been studied by few researchers in the past [5, 6, 14] to evaluate the possibility of using these forests for timber production and they have recommended that dry forests of Sri Lanka are not suitable to be considered as production forests due to slow growth rate of trees and poor natural regeneration of timber tree species. However, recent information on the forest resources, their ecology and the threats prevailing in natural forests in this region are not adequate. Such information is essential in preparing guidelines for the sustainable utilization of dry forests of the region. Therefore, it is worthwhile to consider the ecological features of dry forests elsewhere in the country to generalize the patterns in northernmost dry forests as some basic features are somewhat common to all dry forests of the country. This study reveals the ecological features and threats prevailing in dry forests at three localities in Sri Lanka and compares these with the situation in a dry forest in the Kilinochchi District to describe the floristic features of northernmost dry forests of the country and to make some recommendations for the sustainable management of these forest resources.

II. Research Design and Methods

Experimental sites for this study were selected to represent a diverse array of dry forests of Sri Lanka. Thus, late successional forest at Bandaraketiya in the Victoria-Randenigala-Rantambe (VRR) sanctuary in Badulla District, Scrub forest at Bundala National Park at Hambanthota District and a hill forest at Manewakanda in Anuradhapura District were selected for enumeration (Table 1). Plant species present in these dry forests were enumerated in sixteen $20\times20m^2$ experimental plots established on randomly selected sites. In contrast, the vegetation in the forest at Kilinochchi was detected by a rapid appraisal as there were restrictions for working in these forests. The canopy height in all studied forests was recorded using a clinometer (SUUNTO®) while visual observations were made on the threats to the forests and plant species.

Table 1: Study sites

Study site	Mean annual rainfall (mm)	Forest type	Agro-ecological zone
Bandaraketiya forests in VRR sanctuary	~2000	Tropical seasonal forest	IM1
Bundala National Park	750-1000	Tropical semi-deciduous forest	DL5
Manewakanda forest	1000-1500	Tropical seasonal forest	DL1
Kilinochchi forest	1500-2000	Tropical seasonal forest	DL1

Source for Rainfall data and agroecological zones: The National Atlas of Sri Lanka, 2007

III. Results and Discussion

Hundred and seventeen species have been identified from all four study sites but some species are found to be showing restricted distribution. For instance, the climax forest tree species *Dialium ovoideum* was recorded in MA forest as the species prefers to grow in hill forests with rocky slopes in the dryzone. Rubiaceae, Euphorbiaceae, Fabaceae, Apocynaceae species are prominent in tropical semi-deciduous forests at Bundala in DL5 agroecological zone but with increased moisture levels (as given in Table 1), more Sapindaceae and Loganiaceae species thrive well with other species of aforementioned plant families.

Table 2 clearly shows that the density of individuals, the number of strata in the vegetation profile, species composition and the endemic and threatened plant species present in four forests were not comparable. These may be artefacts of their physical location and subsequent variations in the macro- and micro-climatic conditions and the nature of disturbances (the type, frequency and magnitude).

Fortysix plant species belonging to 45 genera and 23 plant families were found in Bandaraketiya (BK) forest, 40 species belonging to 39 genera and 25 plant families were recorded from Bundala (BU) Forest, 39 species belonging to 36 genera and 19 families were recorded from Manewakanda (MA) forest, but merely a survey of the forest at Kilinochchi (KI) has revealed 28 species belonging to 25 genera and 22 plant families (Table 2). Four strata were observed in the structure of MA and KI forests but only three strata were found in BK and BU forests.

KI forest is a tall forest where the canopy is about 20-22 m (Table 2). *Chloroxylon swietenia*, *Diospyros ebenum*, *Manilkara hexandra* and *Vitex altissima* are present in the canopy while *Drypetes sepiaria* is commonly found in the sub-canopy. *Pterospermum suberifolium* and *Syzygium cumini* trees were also present in the canopy indicating the occurrence of disturbances about 30-40 years back. A characteristic floristic feature of KI forest is the presence of several congeneric species. For instance, *Dimocarpus gardneri* and *D. longan* and, *Strychnos minor* and *S. trichocalyx* grow at the same site. Four endemic species, namely, *Derris parviflora*, *Dimocarpus gardneri*, *E. zeylanicum* and *S. trichocalyx* were found from this survey (Table 3).

MA forest is a hill forest with rocky slopes which grows up to 18-20m in height (Table 2) and contains some endemic species such as *Dialium ovoideum*, *Glenniea unijuga*, *Micromelum minutum* and *Pterygota thwaitesii* (Table 3). Presence of late-seral species such as *Grewia helicterifolia* and *P. suberifolium* in the forest canopy could be considered as an evidence for past disturbances in the site. Selective logging in the recent past has created gaps in the forest canopy that facilitate the growth of light demanding early seral species such as *Carissa spinarum*, *Croton laccifer* and *Toddalia asiatica* with the invasive *Lantana camara*.

Table 2: Comparison of physiognomic and floristic data in dry forests at four study sites

Floristic/physiognomic features	Forest			
	BK (n=4)	BU (n=6)	MA (n=6)	KI
Density of woody spp. (ha^{-1})	3513	4592	2967	--
Average canopy height (m)	15-16	13-15	18-20	20-22
No. of strata	3	3	4	4
No. of families	23	25	19	22
No. of Genera	45	39	36	25
No. of Species	46	40	39	28
No. of endemics	01	--	04	04
No. of threatened spp.	01 (L-VU) 01(G-VU)	--	02 (G-VU)	01 (G-VU)

L= locally threatened; G = globally threatened; VU = Vulnerable)

BK forest is a late successional forest which has grown over a period of about 30 years and its canopy height is about 15-16 m. This rather open forest has grown on human settlement area that had been abandoned due to the construction of Randenigala and Rantambe reservoirs and therefore contains several domesticated plant species such as *Gliricidia sepium*. The forest contains many light demanding species but climax dry forest species are present in very low numbers. *D. parviflora* is an endemic species present in this forest (Table 3). *Haldina cordifolia* is a common tree in the study area which is a threatened species (Vulnerable) according to the 'The National Redlist 2012 of Sri Lanka' [2]. Both these species are late-seral species which indicate the disturbances that have taken place at the site in the past.

Forests at BK, MA and KI belong to tropical seasonal forest category and lies in agro-ecological zones DL 1-4 [1], (Table 1). The threatened (Vulnerable) species; *C. swietenia* [2] is found from all these three forests.

In contrast, the dry forest at Bundala belongs to a tropical semi-deciduous forest (in DL 5 agro-ecological zone, [2]) in which the canopy consists of a single species, *M. hexandra* [7] which grows up to 12-15m in height. However, the site has been damaged in the past by selective logging and shifting cultivation. The area is protected as a National Park since 1992 [10, 15] but the regeneration of natural forest species is hardly being taken place. Moreover, the forest clearly shows the features of a deflected succession to form scrub jungle *plagioclimaxes*. Presence of many thorny shrubs and treelets such as *Dichrostachys cinerea*, *Azima tetracantha* and *Flueggea leucopyrus* may be considered as evidence for this.

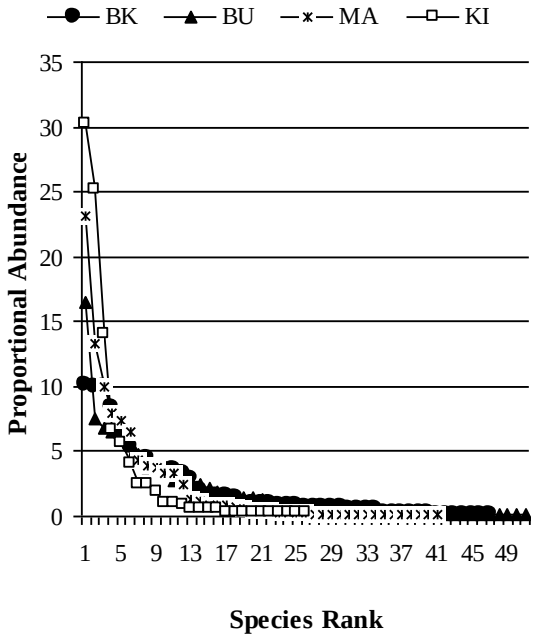

Figure 1: Species rank abundance curves for four study sites

The presence of many light-demanding early- and late-seral species in all four forests indicates the disturbed nature of these forests. The valuable timber species *C. swietenia* is a typical lowland tropical seasonal forest tree but it is rare due to severe selective logging.

Table 3: Frequency of occurance of some woody species, their life form and ecology in different forests

Species	Life form	Ecology	Frequency of occurrence (%) of the common species			
			BK	BU	MA	KI
Atalantia ceylanica	S	ES	5	*	--	--
Canthium coromandelicum	S	LS	10	*	*	--
Carissa spinarum	S	ES	*	6	*	*
Chloroxylon swietenia	T	C	*	--	*	*
Croton laccifer	S	LS	*	--	23	--
Derris parviflora	L	LS	*	--	*	*
Dialium ovoideum	T	LS	--	--	*	--
Dichrostachys cinerea	S	C	*	7	--	--
Dimocarpus gardneri	T	ES	--	--	--	*
Dimocarpus longan	T	LS	--	--	*	25
Drypetes sepiaria	T	C	*	*	10	*
Erythroxylum zeylanicum	S	C	--	--	--	*
Flueggea leucopyrus	S	C	*	7	--	--
Glenniea unijuga	T	ES	--	--	8	--
Glycosmis pentaphylla	S	C	*	--	13	--
Grewia helicterifolia	T	LS	--	--	6	--
Haldina cordifolia	T	LS	*	--	--	--
Lantana camara	S	ES	10	*	*	--
Manilkara hexandra	T	C	--	*	--	*
Micromelum minutum var. ceylanicum	S	C	*	--	7	--
Phyllanthus pinnatus	S	LS	10	8	--	--
Pleiospermium alatum	T	C	6	--	--	--
Polyalthia korinti	T	C	*	--	*	*
Psilanthus wightianus	S	ES	--	16	--	--
Pterospermum suberifolium	T	LS	*	--	--	14
Pterygota thwaitesii	T	C	--	--	*	--
Strychnos minor	S	C	*	--	--	6
S. trichocalyx	S	C	--	--	--	12
Vitex altissima	T	C	--	--	*	5

*species is present in the vegetation at <5% frequency. Endemic species are given in **bold** letters.
S= shrub, T=Tree, L= Liana, ES= Early secondary plant, LS= Late secondary plant, C= Climax plant

In general, early- and late-seral species occur more universally and therefore, such species occur in all studied forests irrespective of their location and forest type but climax forest species, especially the endemic species show a more restricted distribution (Table 3). Eight endemic species were recorded in this study of which, six were found in northernmost dry forests, *i.e.* at MA and KI forests.

L. camara is a common invasive species in BK and MA forests where selective logging has occurred (Table 4). Grazing and browsing in BU forest is a major threat to this ecosystem which is one reason for maintaining its *plagioclimax* state. These give clues that the KI forest would also become degraded unless protected from selective logging, grazing and browsing by feral cattle.

Table 4: Disturbances in dry forets at selected study sites

	BK	BU	MA	KI
Major disturbances happen in the past	Continuous cultivation & a human settlement	Selective logging and shifting cultivation	Selective logging	Selective logging
Prevailing major disturbances	Selective logging, damage by elephants	Invasion by *Prosopis juliflora*; grazing/ browsing by domestic cattle	Selective logging	Growth of *Ficus* spp. on large trees, grazing and browsing by feral cattle
Common invasive plants	*Lantana camara*	*P. juliflora, O. dillenii*	*L. camara*	--

Taxic diversity (Table 2) and the evenness of species distribution (Figure 1) in BK forest was little higher than the rest of the forests which indicate a higher plant diversity in the site. A high sequential dominance of 2-3 species in MA and KI forests might be due to heavy continuous disturbances in these sites.

It is very important to protect the forests in the Kilinochchi District as these are rich in species and harbour several endemic climax forest species. Growing of suitable fruit and timber tree species in home gardens of local villagers together with some fodder and fuel wood tree species may be a timely action in reducing the human pressure on natural forests which undoubtedly contributes to the conservation of the dry forest biodiversity. *Artocarpus heterophyllus*, *Azadirachta indica*, *Chloroxylon swietenia*, *Chukrassia tabularis*, *Manilkara hexandra* and *Tamarindus indica* are some suitable tree species that could be promoted to grow in home gardens in the area. However, plants species for such introductions should be carefully selected and plants with high invasive potential (*e.g. Leucaena leucocephala*) should not be used for the purpose. Finally, actions should be taken to protect the area from aggressive alien exotics. For instance, the aggressive alien exotic *Prosopis julifora* has invaded many parts of the northern Sri Lanka, including Mannar and Jaffna peninsula and efforts should be taken to control the species without allowing their further spreading.

IV. Conclusion

Dry forests are very vulnerable to anthropogenic disturbances so that frequent disturbances would lead to form scrub jungle *plagioclimaxes*. Therefore, the floristically rich northernmost dry forests should be protected from anthropogenic activities such as selective logging, clearance for cultivation and cattle ranching. These forests should be conserved to protect the biodiversity in them. Policies should be formulated to prevent conversion and fragmentation of these forests for the sake of developmental activities as well as to control illegal human activities. Measures should be taken to introduce ecotourism industry to the area while conserving the forests and their biodiversity. Promoting to grow native dry forest timber tree species in home gardens of local villagers together with some fodder and fuel wood tree species would be beneficial in protecting the northern dry forests in the long run.

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